

Achene anatomy in Coreopsidinae (Heliantheae; Compositae) and its systematic implications

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Abstract

Comparative anatomical study of achenes of the *Bidens*, *Chrysanthellum*, *Coreopsis*, *Cosmos*, *Dahlia*, *Guizotia*, *Heterosperma*, *Isostigma* and *Thelesperma* shows a strong similarity in the arrangement of the epidermis, hypodermis, phytomelenin layer, fibrous zone and the parenchymatous zone. Fibrous zone is continuous in all the taxa except in *Guizotia* where fibre bundles are formed. The cells of the seed coat do not show any type of thickening. Present study supports the placement of *Guizotia* in the Subtribe Coreopsidinae as done by Stuessy (1977). However, we suggest placement of this genus in a separate group within Coreopsidinae.

INTRODUCTION

The subtribe Coreopsidinae (Heliantheae; Compositae) is cosmopolitan in distribution with most of its members found in America (Mabberley, 1987). Stuessy (1977) and Robinson (1981) treated Coreopsidinae as one of the subtribes of the tribe Heliantheae but Powell and Turner (1974) suggested a tribal position for this subtribe. The genus *Guizotia* has been placed in Coreopsidinae by several workers (Stuessy, 1977; Baagoe, 1974) but Robinson (1981) transferred this genus to subtribe Milleriinae. This paper endeavours to: (1) examine the achenal anatomy of species of *Bidens* L., *Coreopsis* L., *Cosmos* Cav., *Chrysanthellum* L. Rich., *Dahlia* Cav., *Guizotia* Cass., *Heterosperma* Cav., *Isostigma* Less. and *Thelesperma* Less., to delineate subgeneric grouping within each; (2) to postulate evolutionary relationships among the 9 genera based on seed coat and pericarp

anatomy and (3) to discuss systematic position of *Guizotia*.

MATERIALS AND METHOD

Materials for the present study were obtained from seed herbarium of the National Botanical Research Institute, Lucknow and Herbarium of the Ohio State University, Columbus. The taxa studied and vouchers are listed in Table 1.

Mature achenes were kept in 70% ethyl alcohol for a week. Customary methods of dehydration in Tertiary-Butyl-Alcohol series and embedding in paraffin wax were followed. Microtome sections, cut between 12-20 μm thickness, were stained in safranin - fast green combination. Mature seed coat was dissected out from the achenes and were studied for thickening pattern.

OBSERVATIONS

Bidens L.

The anatomy of the pericarp in *Bidens*

Table 1

Taxa studied	Voucher specimens
<i>Bidens andicola</i> H. B. K.	<i>D. N. Smith & M. Buddensiek</i> 10907
<i>B. aristosa</i> (Michx.) Britt.	<i>Floyd Bartley</i> OS 99323
<i>B. bipinnata</i> L.	<i>Clara Weishaup</i> 2080
<i>B. cynapiifolia</i> H. B. K.	<i>Ricardo Gerbrim Julio</i> OS 120191
<i>B. pilosa</i> L.	<i>Paulo Cjutierbes</i> 10
<i>B. biternata</i> (Lour.) Murr. & Sheriff	<i>Pandey</i> 121
<i>Chrysanthellum indicum</i> DC.	<i>Pandey</i> 521
<i>C. tuberculatum</i> Hook. & Arn.	<i>Cabrera</i> 22301
<i>Coreopsis auriculata</i> L.	<i>Pandey</i> 129
<i>C. bigelovii</i> (A. Gray) Hall	<i>E. B. Smith</i> 3583
<i>C. latifolia</i> Michaux	<i>Crawford</i> 1464
<i>C. maritima</i> (Nutt.) Hook. f.	<i>Elisens</i> s. n. 1984
<i>C. mutica</i> var. <i>leptomera</i> Sheriff	<i>Spooner</i> 2211
<i>C. petrophita</i> A. Gray	<i>Crawford</i> 1389
<i>C. pubescens</i> Elliot	<i>Smith</i> 3739
<i>C. stillmanii</i> Blake	<i>Pandey</i> 322
<i>C. tinctoria</i> Nutt.	<i>Pandey</i> 155
<i>Cosmos bipinnatus</i> Cav.	<i>Pandey</i> 352
<i>C. caudatus</i> Cav.	<i>Khan</i> 5527
<i>C. parviflorus</i> (Jacq.) H. B. K.	<i>Pinkava, Keilm Lehto</i> 13707
<i>C. sulphureus</i> Cav.	<i>Pandey</i> 10
<i>Dahlia pinnata</i> Cav	<i>Pandey</i> 1025
<i>Guizotia abyssinica</i> Cass.	<i>Pandey</i> 1059
<i>Heterosperma ovatifolium</i> Cav.	<i>Descr. Plant.</i> 204
<i>Isostigma crithmifolium</i> Less.	<i>Linnaea</i> 1831
<i>Thelesperma simplicifolia</i> Gray	<i>Guy Nasom</i> s. n. 130007

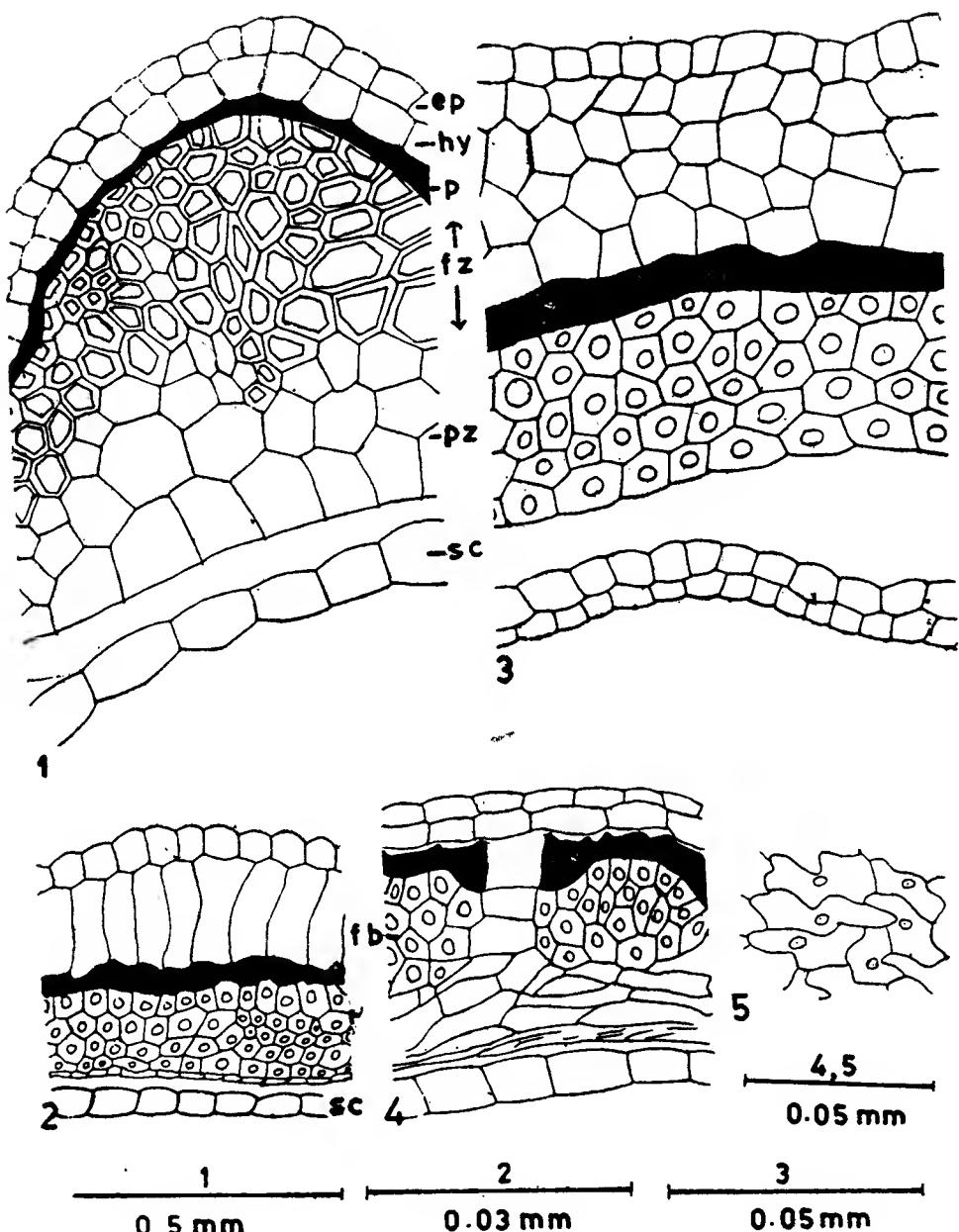
species is basically similar with five distinct zones observable (Fig. 1); epidermis, hypodermis, phytomelanin layer, fibrous zone and innermost parenchymatous zone. The epidermis and hypodermis are single layered. In all the species epidermal cells are small than the hypodermal cells. The thickness of fibrous zone, however, varies. It may vary from 2-4 layered (*B. andicola*), 2-7 layered (*B. cynapiifolia*), 3-5 layered (*B. pilosa*), to 3-7 layered (*B. bipinnata*).

Seed coat is 1 to 2 layers thick. In majority of the species it is single layered except in *B. biternata* where it is 2-3 layers thick. The cells of seed coat do not show any type of thickening (Fig. 1).

Chrysanthellum L. C. Rich.

The mature pericarp is distinguishable into five distinct zones. The outermost zone is represented by single layered epidermis. This zone is followed by 3-4 layered hypodermis. The cells of the latter are larger in size. The third zone is represented by phytomelanin layer. The fibrous zone comprises 3-4 layers of sclerosed cells and is followed by parenchymatous zone. 1-2 layers of isodiametric parenchymatous cells constitute the perenanchymatous zone (Fig. 3).

The seed coat is 1-2 layers thick and the cells of it do not show any type of thickening (Fig. 3).



Figs. 1.5. T. S. part of mature achene. 1. *Bidens biternata*; 2. *Coreopsis tinctoria*; 3. *Chrysanthellum indicum*; 4. *Guizotia abyssinica*; 5. Surface view of seed coat of *Guizotia abyssinica*. (ep-epidermis, fb-fibre bundle, fz-fibrous zone, hy-hypodermis, p-phytomelanin, pz-parenchymatous zone, sc-seed coat).

Coreopsis L.

The mature pericarp consists of five distinct zones in all the species of *coreopsis* except *C. maritima* where the pericarp is distinguishable into four zones. The outermost zone is single layered epidermis of rectangular cells followed by a layer of hypodermis. The number of hypodermal cells, however, increases upto 2 in *C. auriculata*. The hypodermal zone is followed by the continuous phytomelanin layer. The fibrous zone consists of 1-3 layers of sclerosed cells. The innermost parenchymatous zone is present in *C. stillmanii*, *C. auriculata*, *C. pubescens*, *C. mutica*, *C. latifolia*, *C. bigelovii*, *C. petrophila* and *C. tinctoria* (Fig. 2) whereas it is absent in *C. maritima*.

The mature seed coat is composed of 1-2 cell-layers. The cells do not show any type of thickening (Fig. 2).

Cosmos Cav.

The epidermis as well as the hypodermis of the pericarp is single-layered and the cells are rectangular in shape. The epidermal cells are larger than the hypodermal cells. The hypodermis is followed by continuous phytomelanin layer. Below the phytomelanin layer lies the fibrous zone of 4-12 layers of sclerosed cells. The parenchymatous zone consists of 4-12 layers of isodiametric, loosely arranged cells (Figs. 10, 11).

The mature seed coat is composed of 2-3 layers of cells. These cells do not show any type of thickening.

Dahlia Cav.

The pericarp is distinguishable into epidermis, hypodermis, phytomelanin layer, fibrous zone and parenchymatous

zone. Epidermis and hypodermis are single-layered; the cells of former are smaller in size but those of latter are radially elongated. Phytomelanin layer is continuous. The fibrous zone is composed of 2-5 layers of sclerosed cells and parenchymatous zone is 2 cell layers thick.

Mature seed coat is composed of 2 cell-layers. The cells of seed coat do not show any type of thickening.

Guizotia Cass.

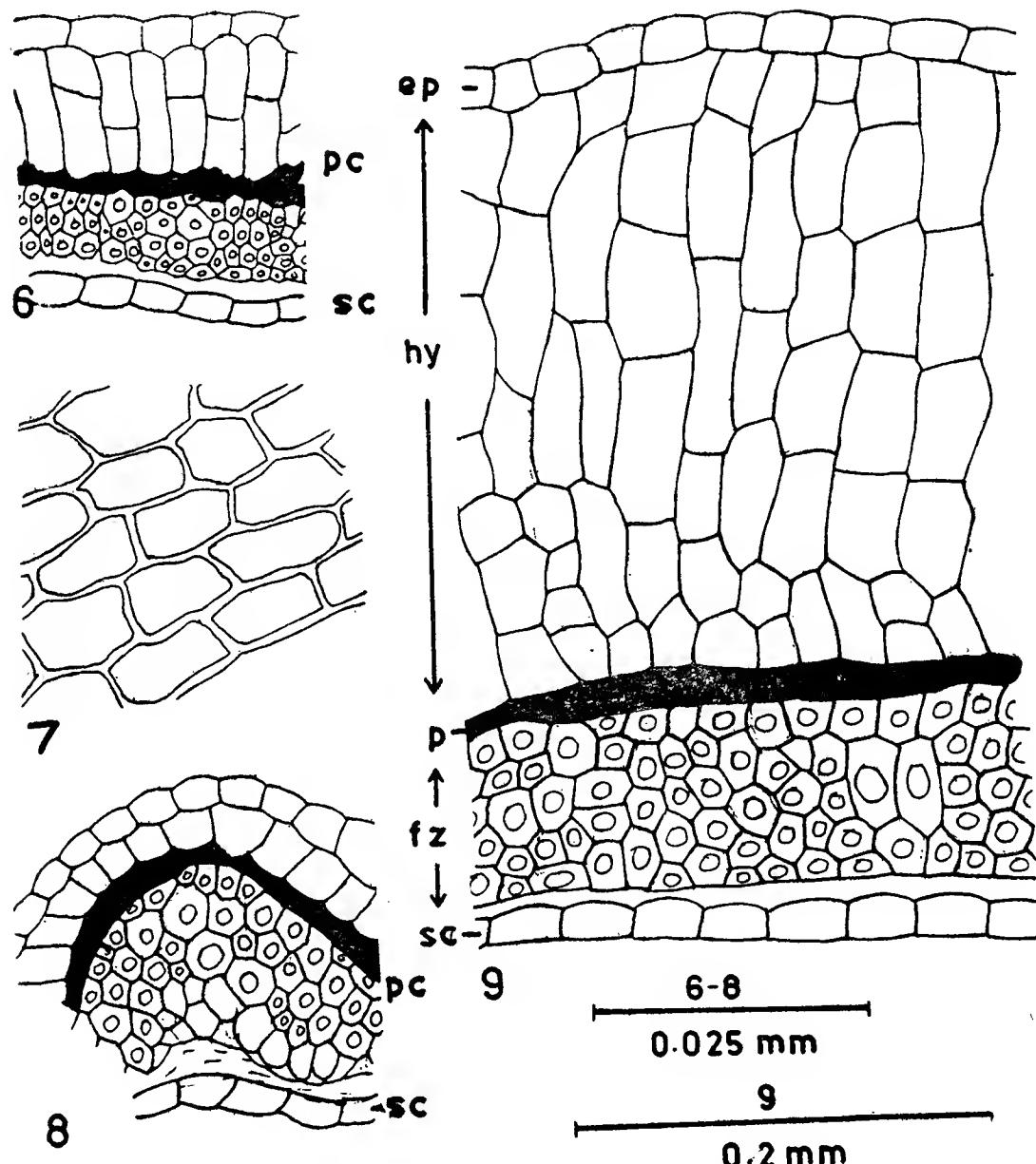
Anatomically the pericarp of *Guizotia* is distinguishable into five zones. Epidermis and hypodermis are single-layered. The cells of both the layers are rectangular in shape. The epidermal cells are smaller than the hypodermal cells. The phytomelanin layer is discontinuous due to presence of parenchymatous trabeculae. The fibrous zone is in the form of bundles. These bundles consist of 21 fibres. The innermost parenchymatous zone is 3 cell-layers thick (Fig. 4).

The mature seed coat is single layered. Seed coat cells in surface view show irregular outline (Fig. 5). These cells do not show any type of thickening.

Heterosperma Cav.

The mature pericarp is distinguishable into epidermis, hypodermis, phytomelanin layer, fibrous zone and parenchymatous zone. The epidermis and the hypodermis are single-layered. At places the hypodermis becomes two layered. The cells of epidermis are smaller in size as compared to the hypodermal cells. The hypodermis is followed by the phytomelanin layer, below which lies the continuous fibrous zone of 2-3 layers of sclerenchymatous cells (Fig. 6).

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Figs. 6-9. 6. T. S. of part of mature achene of *Heterosperma ovatifolia*; 7. Surface view of seed coat of *H. ovatifolia*; 8. T. S. of part of mature achene of *Isostigma crithmifolium*; 9. T. S. part of mature achene of *Thelesperma simplicifolia* (ep-epidermis, fz-fibrous zone, hy-hypodermis, p-phytomelanin layer, pc-pericarp, sc-seed coat).

Table 2

Comparison of Pericarp anatomy

Taxa	Hypodermis	Phytomelanin layer	Fibrous Zone
<i>Bidens</i>	1-layered	Continuous	Continuous, 3-7 layered
<i>Chrysanthellum</i>	4-layered	Continuous	Continuous, 3-4 layered
<i>Coreopsis</i>	1-layered	Continuous	Continuous, 1-3 layered
<i>Cosmos</i>	1-layered	Continuous	Continuous, 4-12 layered
<i>Dahlia</i>	1-layered	Continuous	Continuous, 2-5 layered
<i>Guizotia</i>	1-layered	Discontinuous	Discontinuous with bundles of fibres.
<i>Heterosperma</i>	1-layered	Continuous	Continuous, 2-3 layered
<i>Isostigma</i>	1-layered	Continuous	Continuous, 3-7 layered
<i>Thelesperma</i>	4-8 layered	Continuous	Continuous, 1-5 layered

The seed coat is single-layered and the cells of seed coat do not show any type of thickening (Fig. 7).

Isostigma Less.

The mature pericarp is distinguishable into five zones. Epidermis and hypodermis are single-layered. The cells of hypodermis are larger in size as compared to the epidermal cells. The phytomelanin layer is present just below the hypodermis and is continuous. The fibrous zone is 3-7 layers thick. This zone is followed by 3-5 layers of parenchymatous cells (Fig. 8).

The seed coat is single-layered and the cells do not show any type of thickening.

Thelesperma Less.

The pericarp is quite thick and distinguishable into four zones. Epidermis is single-layered. The hypodermis is composed of 4-8 layers of parenchymatous cells. This zone is followed by phytomelanin layer which is continuous. The fibrous zone is 3-4 layers thick and composed of sclerenchymatous cells (Fig. 9).

The seed coat is single layered and

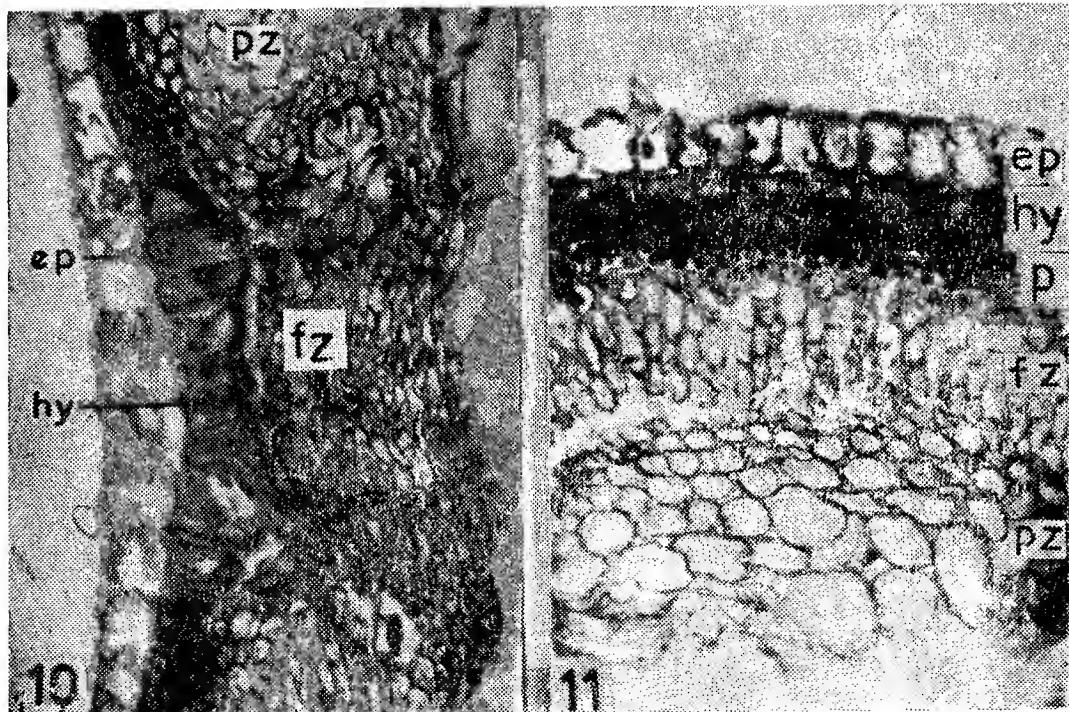
the cells do not show any type of thickening.

DISCUSSION

The anatomy of the pericarp in *Bidens*, *Chrysanthellum*, *Coreopsis*, *Cosmos*, *Dahlia*, *Guizotia*, *Heterosperma*, and *Isostigma* is basically similar with five distinct zones: epidermis, hypodermis, phytomelanin layer, fibrous zone and internal parenchyma. In *Thelesperma*, however, the inner parenchymatous zone is absent. Within each genus constancy of anatomical features exist among the species.

In all the taxa presently studied, phytomelanin layer and fibrous zones are continuous except in *Guizotia* where it is represented by fibre bundles (Table 2). These fibre bundles are separated from one another by means of uniseriately arranged parenchymatous cells. In addition, the organisation of the pericarp is constant throughout the entire length of the achene. Slight variation occurs in the number of hypodermal cell layers and thickness of the fibrous zone, but they are minor and hence do not contradict patterns observed.

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Figs. 10-11. T. S. part of achenes of *Cosmos sulphureus* and *C. bipinnatus* respectively. (epi-epidermis, fz-fibrous zone, hy-hypodermis, p-phytomelanin layer, pz-parenchymatous zone).

The epidermis and internal parenchyma provide no significant taxonomic characters for differentiating the genera studied presently. The hypodermis, however, does. In *Bidens*, *Guizotia*, *Coreopsis* and *Dahlia* it is single-layered throughout the length of achene. In *Heterosperma*, although the hypodermis is for the most part single-layered, at places it becomes two-layered. The hypodermis is 3-7 layers thick in *Chrysanthellum* whereas it is 4-8 layers thick in *Thelesperma*. *Thelesperma* and *Bidens*, differ from *Coreopsis*, *Cosmos*, *Dahlia* and *Guizotia* in having 4-8 layered hypodermis (Table 2).

Subtribe Coreopsidinae is characterised by 1-2 layers thick seed coat and

these cells do not show any type of ornamentation. The cells show somewhat thickened walls in all the taxa studied, except in *Guizotia* where the cells of the seed coat are irregular.

Although, *Guizotia* shows a similar basic pattern of pericarp and seed coat differentiation, it differs from other genera of Coreopsidinae studied presently, in the following characters: (1) fibrous zone represented by fibre bundles, (2) discontinuous phytomelanin layer and (3) seed coat cells with irregular walls.

Genus *Guizotia* has been placed in Coreopsidinae by traditional taxonomists and by Stuessy (1977). Baagoe (1974) transferred the genus to Verbesininae but

later (1977) agreed with Stuessy. Robinson (1981), however, transferred the genus *Guizotia* to subtribe Milleriinae. Stuessy (1977) made seven groups within Coreopsidinae to include various genera.

Based on data from achene anatomy we, however, suggest the placement of *Guizotia* in a separate group within Coreopsidinae and not in a separate subtribe, as has been done by Robinson (1981).

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